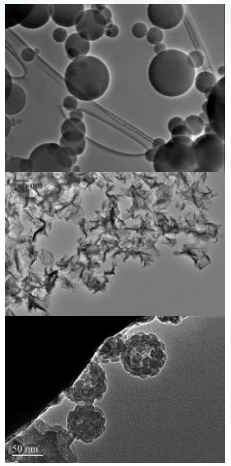
Aerosol Measurement Science

Joe Conny
W. Sean McGivern
Chris Zangmeister



Transmission electron microscopy (TEM) images of aerosol reference material candidates.

Collaborators:

Mingdong Li, UMD
Diana Ortiz-Montalvo, NRC Post-doc
James Radney, Post-doc, UMD
Rian You, Graduate student UMD
Prof. Michael Zachariah, UMD

Thomas Allison
Donald Burgess
Prof. Russell Dickerson, UMD
Courtney Grimes, UMD
Keith Gillis
Joseph Hodges
Cary Presser
Robert Willis, EPA

Past Collaborators:

Sean Collins, SURF Student
Joseph Klems, NRC Post-doc
Alicia Pettibone, NRC Post-doc

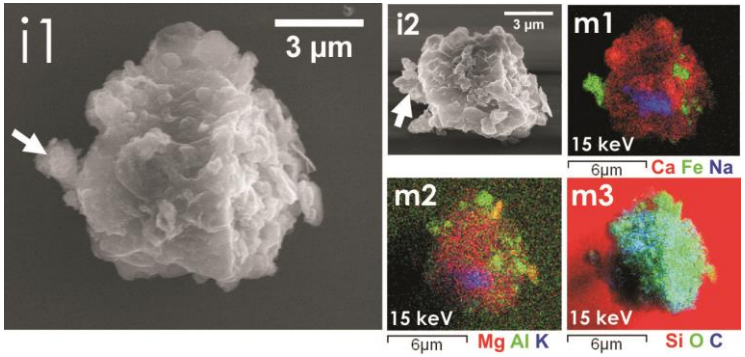
Andy Herzing
Xiaofei Ma, Post-doc, UMD

Aerosol measurement challenges

Aerosols present significant measurement challenges because they are a **Mixture** of particles in a gas with complex and diverse characteristics.

- Phase: Solid or liquid or both
- Size: 10 nm to 1 µm
- Mass: fg to ng
- Shape: all sorts
- Composition: OC, EC/OC, Sulfate, Nitrate, Ammonium, Mineral dust, etc…

- Urban Concentration:
  10^2 to 10^5 particles cm^{-3}
  1 to 100 µg m^{-3}



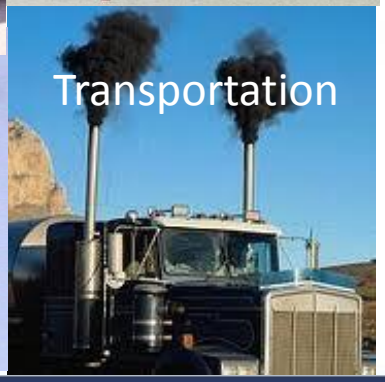
Electron image & element maps particle sample – Los Angeles 2004

- Tropospheric Lifetime - ~ 1 week
- Transport distance –
  ½ way around the world

Sources

Natural

Anthropogenic

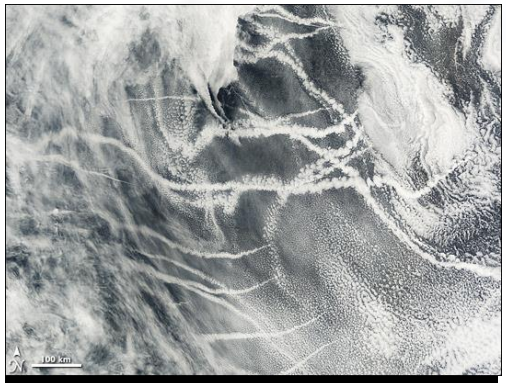


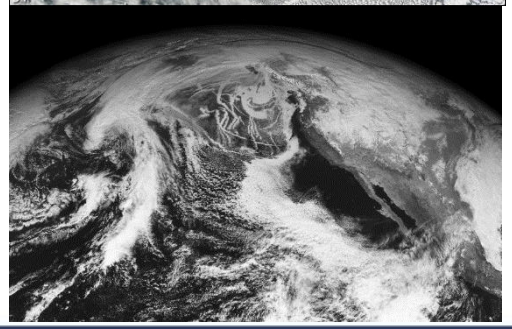
Aerosol impacts

- Warms climate via absorption
- Cools climate via cloud and condensation processes
- Changes surface albedo
- Affects local and global scale weather and air quality

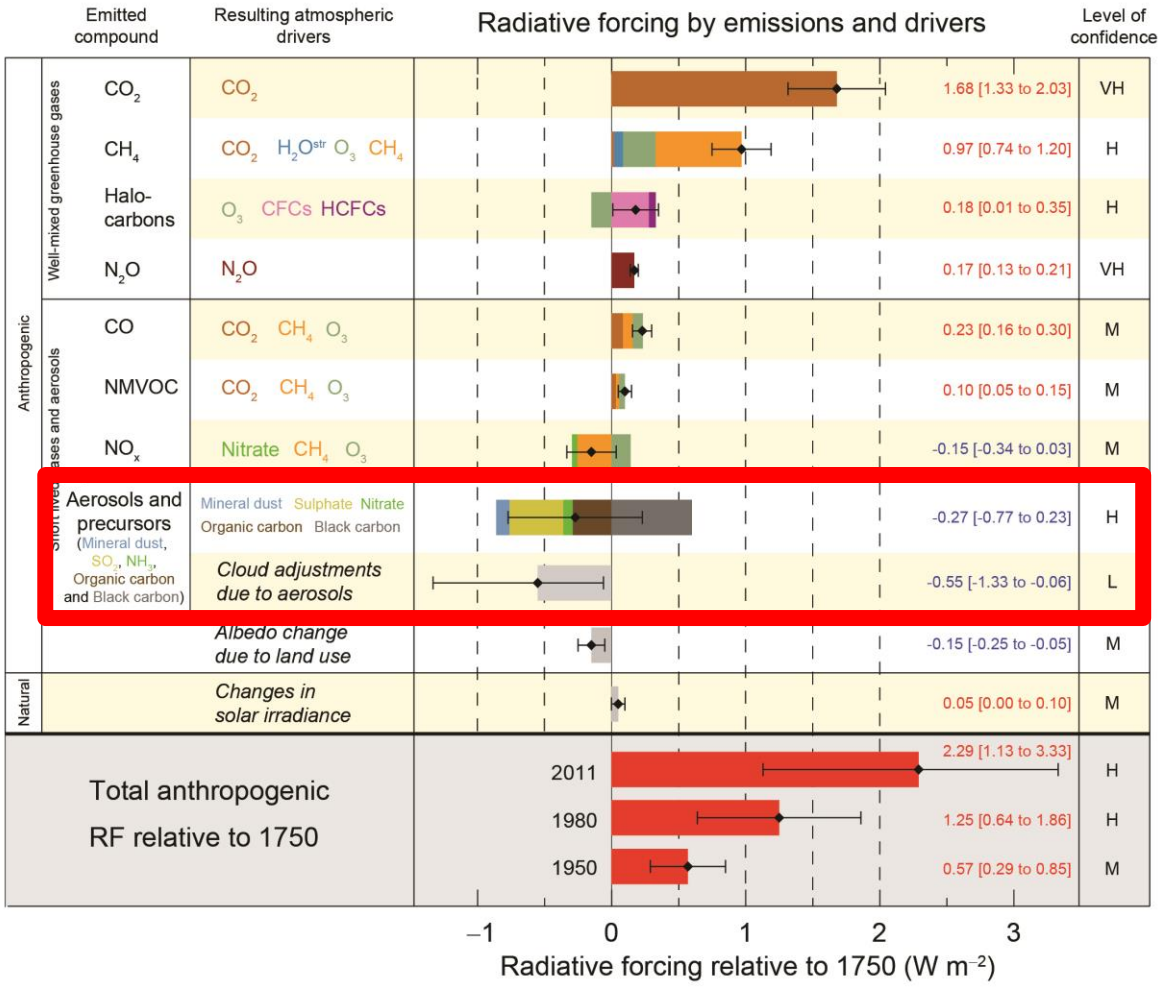
14 ug/m3 loading - Acadia, ME - Out of EPA attainment

886 ug/m3 loading - Beijing, China





Radiative forcing attributed to aerosols



Aerosols:

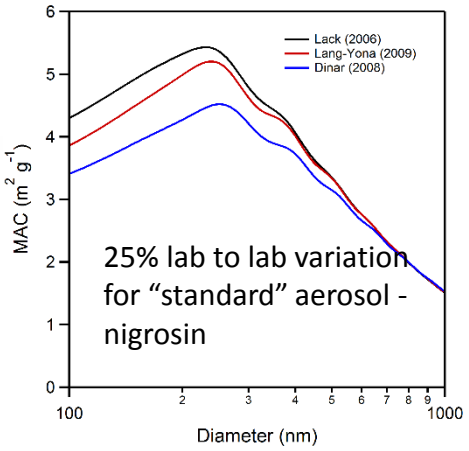
- 2nd leading cause for radiative forcing
- represents ≈75% of forcing uncertainty

UN IPCC 2013

Needs of the communities

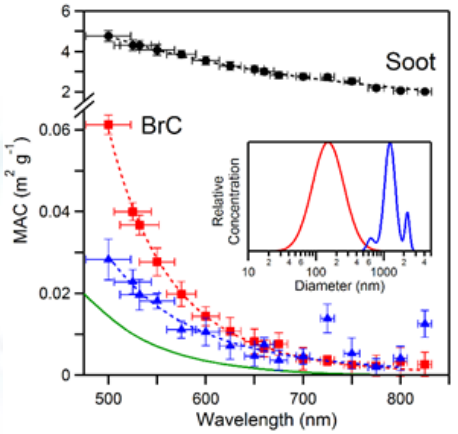
Improved measurements through:

- Traceable measurements
- Standard materials
- Data for materials with known properties
- Methods for measurement intercomparisons
- Improved instrumentation – specificity and sensitivity
- Terminology clarification
- **Cross disciplinary understanding of aerosols, their measurement and the underlying chemistry**



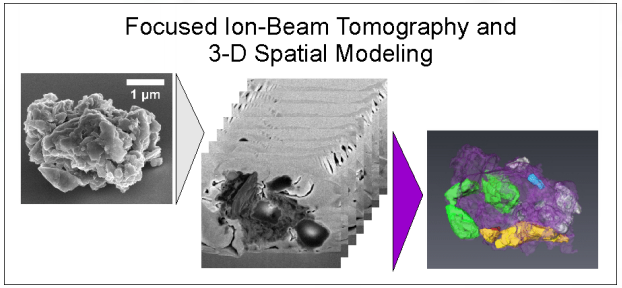
NIST Aerosol projects

- Characterize radiative properties of black and brown carbon systems
  - Develop and apply new optical measurement capabilities
  - Correlate optical properties with chemical composition
  - Develop a transferable aerosol with known optical properties

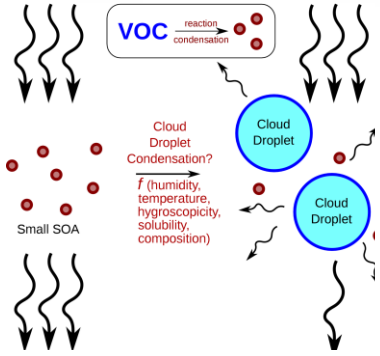


Mass absorption of soot, brown carbon, and BrC Solution

- Microanalysis of heterogeneous aerosols
  - Determine shape, composition, & internal structure
  - Correlate optical properties based on 3-D spatial models



- Organic aerosol chemistry impacting solar radiation
  - Use a photochemical flow reactor to elucidate key VOC oxidation reactions producing chromophores and particulates
  - Characterize droplet formation propensity



Atmospheric aerosol processes

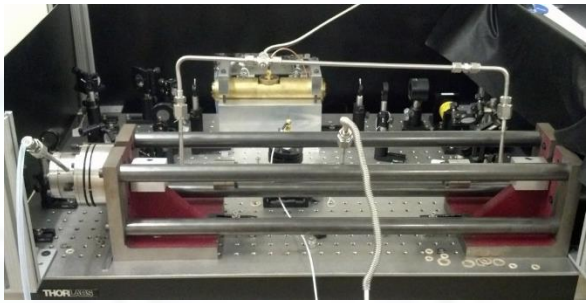
Tools & Expertise

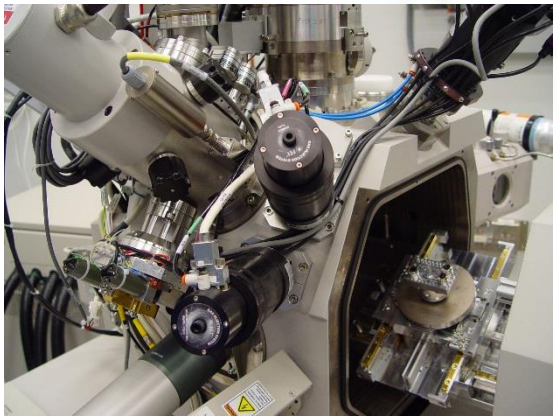
Particle generation
Soot & spray generation
Flow reactor
Conditioning tools

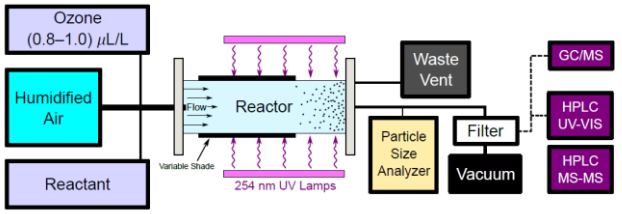
Particle characterization
Size - Differential mobility analyzer
Mass - Aerosol particle mass analyzer
Number - Condensation particle counter
Cloud condensation nuclei counter

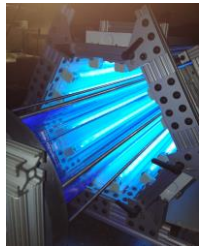
Chemical analysis including 3-D structure and composition
High performance liquid chromatography
Tandem mass spectrometer
Focused ion beam scanning electron microscope with X-ray detection
Transmission electron microscopy
Electron backscatter diffraction
Inductively coupled plasma mass spectrometer

Optical properties
Cavity ring down spectrometer
Photoacoustic absorption spectrometer


Cavity ringdown and photoacoustic spectrometers


FEI Nova NanoLab 600 focused ion-beam scanning electron microscope




Photochemical Flow Reactor to Study Extensive Oxidation of Organic Compounds

Holistic understanding of aerosols and their climate impact

Measurement perspectives for carbonaceous aerosols